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Microhardness of dual-polymerized resin cement around a translucent fiber post in the intraradicular environment

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Abstract

Aim:

In this study, we evaluated the effect of photopolymerization on Vickers microhardness of dual-polymerized resin cement at three locations when a translucent quartz fiber post was used.

Materials and Methods:

Single-rooted bovine teeth received quartz fiber post systems (length: 12 mm) using a dual-polymerized resin cement. In Group 1, the posts were cemented but not photopolymerized, and in Group 2, the posts were both cemented and photopolymerized. After cementation, approximately 1.5-mm thick sections were obtained (two cervical, two middle, and two apical) for regional microhardness evaluations.

Statistical Analysis:

Statistical analyses were performed using the SPSS software (ver. 11.0 for Windows; SPSS, Inc., Chicago, IL, USA).

Microhardness (kg/mm²) data were submitted to two-way analysis of variance (two-way ANOVA) and repeated measures with microhardness values as the dependent variable and polymerization status (two levels: with and without) and root region (three levels: cervical, middle, and apical) as independent variables. Multiple comparisons were made using Dunnett's T3 post-hoc test. *P* values of <0.05 were considered to indicate statistical significance in all tests.

Results:

Photopolymerization did not significantly change the microhardness values when compared with no photopolymerization. Microhardness values also showed no significant difference between the three regions in the root canals in both groups.

Conclusions:

The mode of polymerization of the cement tested in combination with the translucent quartz fiber post system did not affect the microhardness of the cement at the cervical, middle, or apical regions of the root.

Keywords: Fiber posts, microhardness, photopolymerization, resin cement

INTRODUCTION

Fiber-reinforced composite (FRC) posts and cores have been proposed as options or substitutes for cast posts and cores in dentistry. Unlike the latter, which may be cemented with nonadhesive conventional cements, FRC posts should be cemented adhesively. The clinical performance of FRC posts depends substantially on adhesion of the cement to both the root dentin and the post.[1] However, certain factors may affect the retention of posts, such as (1) high cavity configuration factors in root canals (high polymerization stress of resin cements),[2] (2) difficult photopolymerization inside the root canal,[2] and (3) chemical incompatibility between the adhesive system and the self- or dual-polymerized resin cement.[3]

Chemical, dual-, or only photopolymerized adhesive systems and resin cements have been proposed for the cementation of FRC posts.[2,4,5] In the case of photopolymerized adhesives and cements, there is the limitation of access of light through the root canal. This may affect the polymerization, particularly in the apical regions. The use of translucent quartz- or glass-FRC posts

would at least theoretically allow transmission of blue light to the apical regions. However, it has been recently reported that translucent FRC posts do not contribute much to polymerization in the middle or apical regions of the root canal.[2,4,5] The literature reports a degree of conversion of 50–80% for dental composites.[6] In photoactivated resins, the degree of conversion varies inside the mass of the material, partly because of dependence on light energy for activation.[7] Some studies showed a significant decrease in the polymerization potential of composites in the intraradicular environment as a result of less light attenuation.[5,8,9] The degree of conversion achieved by a composite provides valid information about the durability and biological safety of the restoration because it affects the mechanical properties and degradation by water and oral acids.[10] The release of uncured residual monomers presents a potentially sensitizing and irritating factor for the oral tissues.[11,12] Lack of adequate polymerization, principally in the apical region, may also lead to elution of monomers to the apical foramen.

The objective of this study was, thus, to evaluate the effect of photopolymerization on Vickers microhardness of dual-polymerized resin cement at three locations of the intraradicular environment: the cervical, middle, and apical parts of the root canal. The null hypotheses tested were that (a) cervical parts of the roots would show reduced microhardness and (b) photopolymerization would increase the microhardness.

MATERIALS AND METHODS

Soft tissue was cleaned off single-rooted bovine teeth ($n = 10$) using periodontal curettes. The teeth were stored in distilled water at 4°C until use. The coronal and root portions of the teeth were shortened under water-cooling to standardize the length of the specimens at 16 mm. The root canals were sequentially instrumented (Profile Orifice Shapers System, Dentsply Maillefer, Ballaigues, Switzerland) and irrigated with 0.5% sodium hypochlorite.

Root preparation was performed with a slow-speed calibrated drill (size no: 3) of a two-stage, parallel-sided quartz-FRC post system (Light-Post, Bisco, Schaumburg, IL; $\varnothing_{\text{apical}}$: 1.4 mm; $\varnothing_{\text{middle-coronal}}$: 2.2 mm; length: 20 mm; fiber type: 70 wt% preimpregnated unidirectional quartz fibers in 30 wt% epoxy resin; $\varnothing_{\text{fibers}} \approx 12 \mu\text{m}$). They were then randomly divided into two groups according to whether or not they underwent photopolymerization. The cemented post length was standardized at 12 mm. All roots received two coats of black nail varnish to ensure that conversion of the cement was only due to light transmitted through the posts.

After preparation of the root canals, 3 mm of the root portion was embedded in a PVC cylinder (height: 5 mm; diameter: 7 mm) using chemically polymerized acrylic resin (Dencrilay) to facilitate immobility of the root during post cementation. The following procedures were performed during embedding: (a) grooves were prepared on the external apical portion of the specimens with a diamond bur (no. 3195, KG Sorensen, SP, Brazil) to provide mechanical retention of the specimens within the acrylic resin; (b) the preparation bur of the post system was placed inside the prepared root canal; (c) this assembly was attached to an adapted surveyor so that the long axes of the bur, specimen, and cylinder were parallel to one another and to the y -axis; and (d) the acrylic resin and its monomer (AutoPlast, Candulor AG, Altstätten, Switzerland) were mixed and poured into the PVC cylinder.

A multiple-bottle, total-etch adhesive system (All-Bond 2, Bisco) was applied to the root dentin following the manufacturer's protocol when cementing the FRC posts. After adhesive application using a microbrush (Cavi-Tip, Svenska Dental Instrument AB, Värby, Sweden), excess was removed using paper points. The specimens were then randomly divided into two groups ($n = 10$, 5 per group):

Group 1: The posts were cemented with the dual cement (Duo-Link, Bisco) and not polymerized.

Group 2: The posts were cemented with the same cement as in Group 1, and the cement was photopolymerized for 40 s (Optilight Plus, Gnatus; light intensity: 500 mW/cm²) by applying the light from the most superior part of the post.

To condition the FRC posts, FRC posts of size 2 ($\varnothing_{\text{apical}}$: 1.4 mm; $\varnothing_{\text{middle-coronal}}$: 2.2 mm) were first etched using 37% H₃PO₄ for 1 min, rinsed and dried, and then cemented with the dual cement (Duo-Link, Bisco). After cementation, the specimens were stored in distilled water at 37°C for 24 h.

Production of specimens for microhardness measurements

The specimens were fixed to a metallic base in a cutting machine (LabCut 1010, Extec Corp., London, England) and sectioned perpendicular to the long axis of the root with a diamond disc under water-cooling.[14] Initially, a 0.5-mm cut was obtained and discarded. Then, six disc-shaped slices of approximately 1.5-mm thick ($n_{\text{root region factor}} = 20$; $n_{\text{light cure factor}} = 30$) were obtained (two cervical, two middle, and two apical) for the regional microhardness evaluation.

Microhardness measurements

The specimens obtained were embedded in acrylic resin (AutoPlast) for microhardness readings. The specimens' surfaces were finished and polished with silicone carbide papers in sequence (grit nos. 600, 800, 1200, 1400, and 2000) for 60 s each in a polishing machine at 300 rpm under running water. The specimens were then analyzed for Vickers hardness (FM-700, Future-Tech, Equilam, Diadema, SP, Brazil).

The specimens were submitted to a 50-g load for 30 s, and three readings were obtained from three different regions of each specimen.[14] The mean microhardness (kg/mm^2) of each specimen was obtained from these three readings.

Statistical analyses

Statistical analyses were conducted using the SPSS software (ver. 11.0 for Windows; SPSS, Inc., Chicago, IL, USA).

Microhardness (kg/mm^2) data were submitted to two-way analysis of variance (two-way ANOVA) and repeated measures with microhardness as the dependent variable and polymerization status (two levels: with and without) and root region (three levels: cervical, middle, and apical) as independent variables. Multiple comparisons were made using Dunnett's T3 post-hoc test. P values of <0.05 were considered to indicate statistical significance in all tests [Table 1].

RESULTS

Photopolymerization did not significantly affect the microhardness values ($P = 0.2239$; two-way ANOVA). Microhardness values also showed no significant difference among the three regions in the root canals ($P = 0.1621$). The interaction effect was insignificant ($P > 0.05$).

The mean microhardness values obtained with and without photopolymerization were also not statistically significantly different in the three root regions ($P > 0.05$; Table 2).

DISCUSSION

Dual-cure resin cements were developed with the objective of combining the favorable characteristics of self- and light-activated cements. These characteristics include effective control of working time and the possibility of achieving adequate degree of conversion even in the absence of light.[14] Other advantages of dual-polymerized cements are their low solubility and superior mechanical and adhesive properties. In fact, such cements are ideal for situations in which the opacity of the restoration, cavity depth, or root canal may make it difficult for light to reach the full thickness of the cement layer. However, although the two forms of activation of the curing reaction are present, they are complementary and independent. If light exposure is insufficient, the light-activated route of conversion will be affected and maximum polymerization can be compromised.[15] Nevertheless, intraradicular adhesive cementation still presents a significant challenge to clinicians because of the technical variables that are involved and there is little knowledge about the clinical predictability of these materials in the long term.[16] The results of this study indicate that light transmission of the tested translucent quartz FRC post was sufficient to achieve similar microhardness of the dual-polymerized resin cement at the cervical, middle, and apical regions of the root canal. Thus, the first hypothesis was rejected. Microhardness test results reportedly provided an indirect measurement of the polymerization quality of composite resins.[6] Microhardness test results have also been shown to correlate well with Fourier-transform infrared spectroscopy analysis: when hardness values increase, the degree of conversion also increases, and vice versa.[6,17] Thus, the hardness measurement results obtained in this study indirectly indicate that a higher degree of conversion of dual-cured resin cement may be attained using light-transmitting FRC posts. Despite relative hardness as an indication of the extent of polymerization, factors such as load content, type of monomer, concentration of diluents, activation mode, and type and quantity of initiators also play important roles in their respective properties.[14]

In the absence of light, some dual-cured cements reportedly do not reach an adequate degree of conversion.[6,12] Thus, light-curing is also recommended for dual-cured resin cements. Here, the dual-cured cement tested demonstrated microhardness similar to that of the cement tested with and without photopolymerization, resulting in rejection of the second hypothesis too.

Studies on the function of translucent posts in terms of cement polymerization are controversial.[13,18,19] Generally, impaired adhesion was presented in the studies that dealt with differences in adhesion along the post space. Sinhoreti *et al.*[18] observed lower microhardness in deeper regions of the root canal, where less light is delivered. Pedreira *et al.*,[13] however, reported that microhardness did not vary significantly along the apical thirds of the roots for Panavia and Unicem. They found significantly higher microhardness at the cervical third for both Variolink and Duo-Link, but the mean values were not significantly different between the middle and apical thirds for these cements. On the other hand, the results of a recently published study indicate a decrease in Vickers hardness from coronal to apical for fiber posts.[19] Future studies should assess whether there is a correlation between adhesion test results and microhardness measurements for testing reliability of dual-polymerized cements in the root canal. Against these possible explanations, photopolymerization of the dual-cured cement used in combination with FRC posts may be the best practice for the initial polymerization fixation of the post during further chemical polymerization processes.

CONCLUSIONS

Photopolymerization did not contribute to a significant improvement in microhardness of the cement, and the absence of light did not affect adhesive cementation of the quartz FRC post with the cement tested.

Footnotes

Source of Support: Nil

Conflict of Interest: None declared.

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Figures and Tables

Table 1

Results of two-way analysis of variance

Source	DF	SS	MS	F	<i>P</i>
Photopolymerization	1	11.147	11.1465	1.59	0.2239*
Within	18	126.460	7.0256		
Region	2	12.970	6.4852	1.92	0.1621*
Between	2	3.603	1.8017	0.53	0.5920*
Within	36	121.914	3.3865		
Total	59	276.095			

*No significant difference

Table 2

Mean microhardness values (kg/mm²) and standard deviations associated with the location in the root canal without (Group 1) and with photopolymerization (Group 2)

	Root regions			
	Cervical	Middle	Apical	
Group 1	41.85 (3.2) ^{a,B}	40.47 (2.0) ^{a,B}	41.72 (1.4) ^{a,B}	41.34 (2.3)
Group 2	42.04 (1.9) ^{a,B}	41.81 (2.4) ^{a,B}	42.77 (1.5) ^{a,B}	42.21 (1.9)
Total	41.94 (2.6)	41.14 (2.2)	42.24 (1.5)	

The same small superscripts in each column and the capital superscripts in each row show no significant differences, ^a*P*<0.05

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